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**A Technical Review Of Martin Marietta Manned Space System's
Implementation Of Computervision's Engineering Data Management
(EDM) Product**

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Abstract

Computervision's EDM was implemented at Martin Marietta Manned Space Systems in a production mode in December, 1993. This paper discusses the project background, the rationale and approach taken to implement, the role of EDM in the "new" engineering environment, and the lessons learned during the implementation process. Additionally the paper discusses the current EDM configuration and workload supported in today's environment. While this paper focuses on EDM, it is written to cover the process of implementing change into a business environment.

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March 05, 1995

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1.0 Background

Company Background:

Martin Marietta Manned Space Systems is located in New Orleans, Louisiana at the NASA owned Michoud Assembly Facility (MAF). MAF is a part of the Marshall Space Flight Center based in Huntsville, Alabama. Martin Marietta Manned Space System's primary product is the External Tank (ET) for the Shuttle Transport System (STS). The ET is one of three major components and the only expendable element of the STS. The role of the ET is to contain and provide the cryogenic fuels for the Shuttle's Main Engines during lift off. Additionally, the ET is the structural backbone of the STS and provides the attach points for the Orbiter (ORB) and the Solid Rocket Boosters (SRBs). It is designed to absorb and dissipate the 6.6 million pounds of thrust loads generated at and during launch. The ET is 154 feet in length, 27 feet in diameter, its skin thickness is less than 1/2" thick, and is covered by a sprayed on foam insulation (SOFI) thermal protection system. The ET weighs 66,000 pounds empty. There are three major ET components: the liquid oxygen (LO2) tank, the Intertank, and the liquid hydrogen (LH2) tank. The LO2 tank holds 1,390,00 pounds of oxidizer at a temperature of -297° Fahrenheit. The LH2 tank holds 232,000 pounds of fuel at a temperature of -423° Fahrenheit. The propellants are delivered to the Orbiter's engines at the rate of 1,035 gallons per second. At this rate, it takes only 8 1/2 minutes to empty the ET in flight. The Intertank is used to join the LO2 and LH2 tanks and contains the main thrust beam which serves as the forward attach point for the SRBs.

Personal Background:

I have been working in CAD Applications at Manned Space Systems since 1984 and had the Lead responsibility for the acquisition, testing, refining the role of, and implementing EDM. I am currently the Group Lead for the MIS Engineering Systems Support CAD Applications Group which has as one of its responsibilities the on-going operation, customization and expanded utilization of EDM at Martin Marietta Manned Space Systems.

We began our investigation of EDM (then known as PDM) about 1988. Our hands-on testing started with the Sun version of EDM 4.x on a CV 45S server in 1990. After determining that this product did not meet our conceptual requirements and many long discussions with CV management, we became a beta site for EDM 5.0 in 1991. After release of the EDM 5.0 we began extensive testing of both our conceptual requirements, limits and failing of EDM's advertised capabilities, identification of those areas which fall into communication problems (the vendor's solutions did not meet our problems due to the vendor's interpretation of the problems, in other words we established a common dictionary of terms and processes with CV marketing and development staff). It was at this time (1992) that Martin Management at this location

embarked on the implementation of a project known as the CAP (Computer-Aided Productive) Initiative which completely changed the way we conduct business.

2.0 Computer-Aided Productivity (CAP) Project

Overview:

In order to understand the role of Computervision's Engineering Data Management (EDM) system at Manned Space Systems, there must be a level of understanding of what drove the requirement for its implementation.

In early 1989, Martin Marietta Corporation identified the critical need to modernize and enhance business operations to improve quality/cost competitiveness and customer satisfaction. Martin Marietta Manned Space Systems identified the Computer-Aided Productivity Initiative as a major element supporting its long-range planning objectives in the 1990's.

The CAP Philosophy mandated the overall integration of engineering, manufacturing, procurement, support services, and financial information. This integration would provide a shared data repository for all who need information in support of the business. The old timers will remember this as the Computer Integrated Manufacturing (CIM) philosophy, which evolved into Computer Integrated Operations (CIO) and is known today as Business Process Re-Engineering (BPR). The buzz words have changed, but the main philosophies are the same.

The approach taken by Martin Marietta Manned Space Systems was to:

- Utilize commercial off-the-shelf (COTS) software systems and solutions wherever possible.
- Select hardware and software suppliers with demonstrated capabilities to assure project success.
- Establishment of an environment that uses Information Engineering Techniques and Computer-Aided Software Engineering (CASE) Tools throughout the systems development cycle for non-COTS solutions.
- Provide for the reduction of data redundancy by effectively integrating and interfacing applications.
- Integrate the CAP Initiative into the Total Quality Management (TQM) program.

The CAP Project consists of five modules: (1) Integrated Business System (IBS), (2) Integrated Manufacturing System (IMS), (3) Integrated Facilities System

(IFS), (4) Quality Management Solution (QMS), and (5) Product Definition System (PDS).

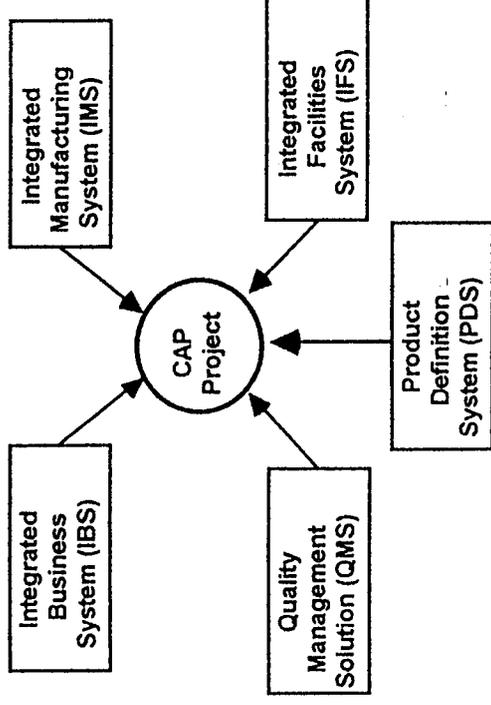


Figure 1 - Overview Of The CAP Project

The module which this paper will focus on is the PDS module and more specifically the Data Generation and Release Process, since the EDM system was implemented to support these project objectives.

For clarity, Product Definition is the activity that designs, develops, tests, and manages the data products and associated processes required to define and support a specific project. The Product Definition System is a set of tools, databases, and procedures utilized during the product definition activity.

The Product Definition System Team baselined the following as its goals:

- Establishment of a Product Definition Information and Configuration Control System which would provide:
 - Technical Data Management.
 - A Production Data Information System which when accessed from any workstation or microcomputer, provides for the storage and retrieval of contractual documents (DRDs), and provides on-line access to ET Flight Hardware Product Definition.
 - Status and Accounting.
 - Automated Electronic Configuration Control.
- Develop new ways of performing the following processes:
 - Change System.
 - Data Generation and Release.

- Build Support.

- Provide an environment conducive for the use of Concurrent Engineering / Integrated Product Development (CE/IPD) methodologies.

The PDS computer environment consists of an IBM ES9000 mainframe located at Marshall Space Flight Center (MSFC) in Huntsville, Alabama supporting the IBM ProductManager (PM) database application, and at MAF a Sun 4/490 supporting the Computervision EDM database application, a VAX 9000 supporting various analysis applications, and an assortment of PC based Banyan Vines network servers. These hosts / servers are accessed via network connections from Sun workstations, MicroVAX workstations, and MacIntosh and PC microcomputers. This current access is provided not only to MAF based systems, but systems at MSFC and Kennedy Space Center (KSC). This access is also being expanded to support design activities with our customer (NASA) and sub-contractors across the country.

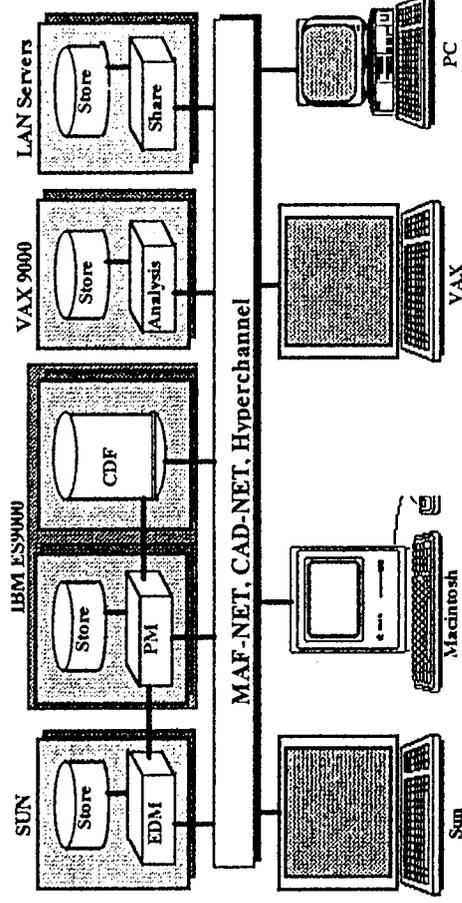


Figure 2 - PDS Computer Environment

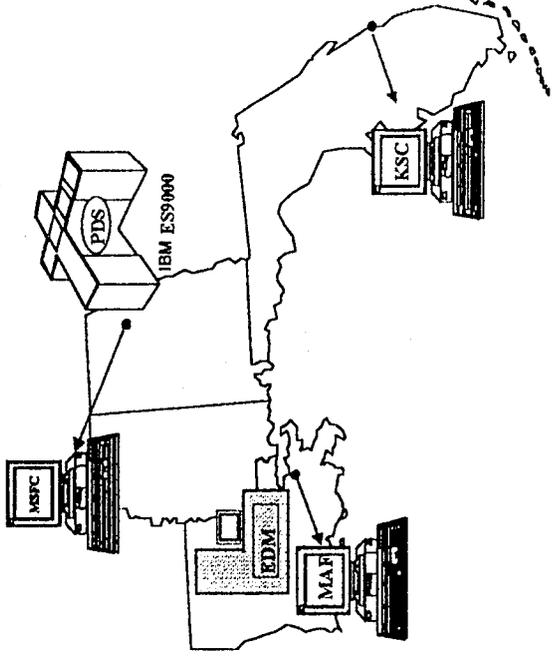


Figure 3 - PDS Architecture

The PDS Team identified and implemented several new tools to support the environment. Two of which are:

- IBM's ProductManager (PM) for enterprise level control of data and products. PM would perform the following functions:
 - Initiate Product Definition activities.
 - Distribute Assignments.
 - Relate Parts to their Documents.
 - Provide electronic review and approval.
 - Release and control data products.
 - Provide knowledge capture / change history.
 - Store Part attributes, Bill Of Materials (BOM), Usage and Effectivity Data, Revision Status.
- Computervision's (CV) EDM for the Local Data Manager (LDM) control and storage of CAD products. EDM would perform the following functions:
 - Centralized backup of "In-Work" CAD data.
 - Provide for the sharing of "Pre-Released" CAD data.
 - Serve as a LDM for PM by providing the controls for "In-work" and "Pre-Release" data locking for reviews. Data locking, management, and controls for the Release (as authorized by PM)

- of all PDS CAD data products including FrameMaker generated engineering Sheet 1 documents.
- Provide the flexibility to perform and manage Release and Configuration Control for non-PDS controlled CAD products within the same system.
- Provide the ability to access data from non-CAD workstations (MACs and PCs running eXodus X-Windows emulation) for the viewing of CAD products. Two additional products are utilized to support this requirement. Frameviewer is used to display the Sheet1 FrameMaker documents and CV's View and Markup product is used to display CADDs drawings.

The project team's selection of IBM's PM application as the enterprise data manager and EDM as a LDM (local data manager) for CAD and CAD related products was driven by limitations of both vendor's applications, physical locations of the host systems (data transfer response concerns), and management directive.

3.0 EDM Implementation Approach:

An existing CAD Working Group Team (CADWG), which was made up of user representatives, in most cases actual CAD end-users, from all CAD using departments would be empowered to be the review and approval authority for all changes, modifications, and/or additions to the EDM environment, e.g.; addition of attributes, approval of new projects, changes in configuration, customization of EDM, etc. The team established the following Guideline Rules for the implementation and transition to EDM:

- EDM would be configured such that it could be utilized by both PDS and Non-PDS compliant CAD using departments.
- EDM would be identified as the only authorized means for the storage, backup, and archival of official CAD design data.
- The mandatory attributes required for PDS were reduced to five attributes. These were established in such a way that they could be utilized by non-PDS departments for their tracking purposes. The value assigned to the attributes would be controlled by the using departments for their project. Example: The attribute JOB_ID is defined for the PDS project as containing the Engineering Change Number, in the POPS project as Tool Order Number, and in FAC project as Request For Facilities (RFF) number. This reduced the overhead of establishing many different attributes and positioned the non-PDS departments to migrate at a later date into the PDS environment with a minimum of impact.

- Each using department was required to have a CADWG approved initial User Guide in place prior to receiving authorization to begin transition to EDM.
- All requests for customization or changes to EDM would require CADWG approval, and where possible, would be accomplished in such a manner that they could be utilized by all EDM users independent of Project. This would reduce the overhead needed to develop and maintain the customization by reducing the amount of redundant customization.

The CADWG team then developed an implementation / transition plan which minimized the risks and impacts on the current production CAD activities and met the schedule requirements of the CAP/PDS project. A three phase plan was developed to meet these requirements. It should be noted at this time that the ET was designed on the drafting board in the 70's and converted to CAD models in the early 80's. This along with the added use of CAD for Tool design and Facilities site and plant management has resulted in an extensive legacy database of design information. It is this legacy data which had to be migrated in to the new EDM environment as well as, positioning EDM to accept and support the NEW way of doing business as defined by CAP / PDS. The Phase I and II activities were driven by requirements generated by CADWG. Phase III was driven by requirements from the PDS System Design Team and implemented and tested by CADWG.

EDM Implementation / Transition Plan:

- Phase I
 - Migrate all in-work CAD data to EDM for configuration control and site standard backup capability for CAD data.
- Phase II
 - Migrate all Released CAD data into EDM for configuration and access control. The current processes used to "Release" CAD data would continue until the implementation of PDS defined "Release" procedures.
- Phase III
 - Customize the EDM application to provide the in-work and release processing controls required to support the processes defined by the PDS Process Definition and Improvement Team.

Phase I activity began in March of 1993 and Phase III was completed and EDM was successfully implemented in December 1993.

4.0 EDM's Role:

EDM has provided the ability to extend PM's configuration control by performing the function of a Local Data Manager for the release and control of PDS CAD data products. This has been accomplished by assigning ownership of released PDS CAD design data to PM and creating scripts which provide PM control over the issuance of "Release" status for PDS design data. These scripts are activated by a "man in the loop" process today, but will be accessed directly by PM via an electronic interface currently in development.

EDM has also provided configuration control for in-work and released CAD data for non-PDS projects.

Additionally, it provides the following for all EDM users, both PDS and Non-PDS:

- Data access control filters for read/write/modify of EDM stored data.
- Check-in / check-out controls.
- Data modification lockouts at specific design Milestones.
- Centralized, shareable data repository for CAD design products.
- In-work flow controls and notification.
- A centralized and controlled backup for all CAD design products.
- Audit trail information.
- The ability to group/query/retrieve data by project/task/ECN using attributes information.

5.0 EDM Customization:

There were only a few areas in which customization was required. They were:

- The PDS Project where four statuses were defined for work flow control. Some internal (EDM triggers) and external (CI scripts) were required to make this flow work as required (See figure 1-5). The non-PDS projects are currently looking at this flow to see if it can be adapted to their work flow needs.
- The interface to EDM. When the interfaces provided by CV, EDMPower and EDMPro did not meet all of our requirements we developed an in-house interface to supplement CV's interfaces. With the CV decision to drop the EDMPro interface for EDMAxess interface it was decided that we would incorporate all of our requirements into one home grown interface (EDMI) and reduce the impacts on our users caused by vendor's decisions. EDMi was

subsequently enhanced to accomplish all of our requirements and to simplify the end users involvement with EDM. EDMI now performs several checks, tests, and processing of data prior to actual movement of data to and from EDM. This activity is accomplished via scripts and EDM CI calls.

- The introduction of an Optical Read/Write Jukebox for near-line archival and specialized backup of released data. When the use of magnetic tape systems did not meet our data retention requirements due to special handling, refresh, and storage area and environmental requirements, as well as, the desire to reduce retrieval times, a decision was made to incorporate the use of Optical technology as the long term data retention solution. The EDM product did not support this approach; therefore, with CV's assistance a set of specialized scripts were implemented to meet our needs.
- Additionally, there is a requirement for a customization which will provide an automated electronic interface between the IBM PM system and EDM. This interface is being developed by ITI and is scheduled to be in place mid-1995. It will enable the following capabilities:
 - Allow PM to initiate a CAD design task in EDM.
 - Allow EDM to notify PM when a file or part changes to Blue status.
 - Allow PM to initiate the change to release (white) status.
 - Allow PM to control access to EDM data for review from non CAD platforms.

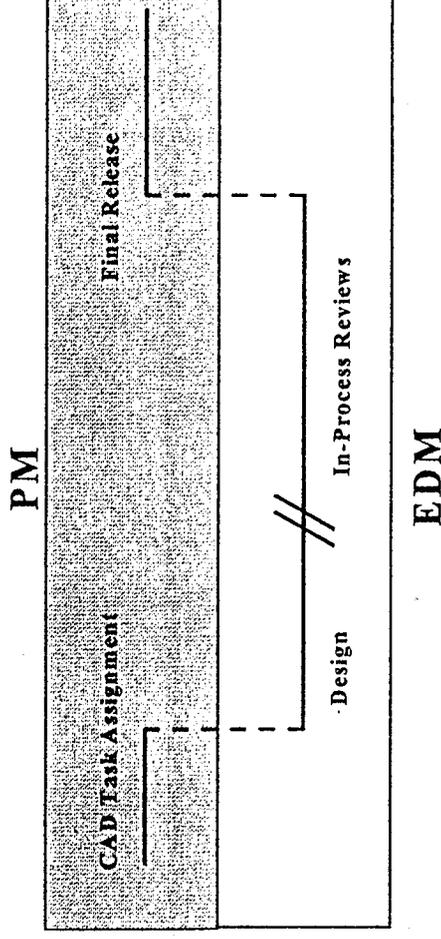


Figure 4 - PDS CAD Work Flow

EDM In-Work Process

Project Setup

IW (InWork)
 Blue = Status Level 10
 Green = Status Level 30
 White (Release) = Status Level 50
 = Status Level 90

Green Release Initiated By The Designer

Request For Blue Release Initiated By The Designer Via A Request For Review.
 Requires Group Lead Approval And Design Support Approval To Change Status
 White Release Initiated By EC Release In PM Currently Requires Design Support Initiation

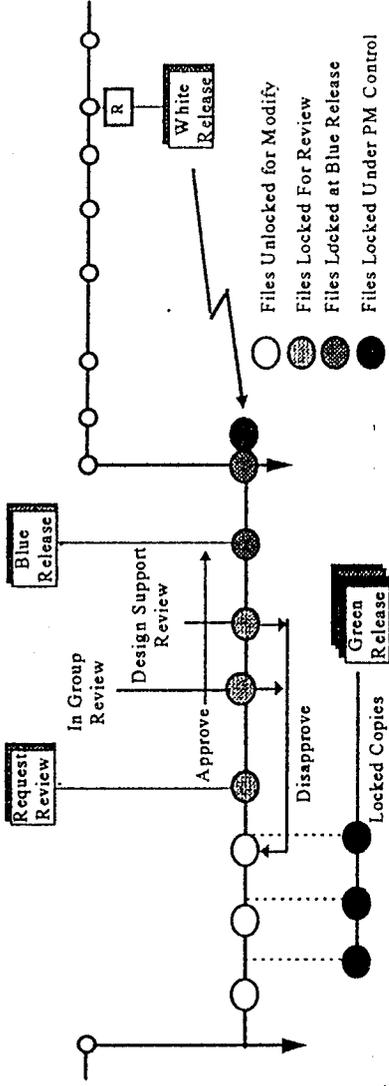


Figure 5 - EDM In-Work Flow

6.0 EDM Configuration:

EDM 5.0/Oracle 6 / SunOs 4.1.3 running on a Sun 4/490 (CV's 49S) was phased into the production environment in May of 1993 as a data vault. The CAP defined usage of EDM was implemented in December of 1993. We are currently running EDM 5.1.2/Oracle 7/SunOS 4.1.3. The 4/490 is configured with 12 each 1.03GB disks, 64 MB memory and multiple tape units both 1/2" and 8mm. The system also contains an 88 platter, 4 drive, Read/Write Optical Jukebox which provides approximately 100 GBs of near-line storage. A hardware upgrade to a Sun 2004 (4 CPU) configured with 512 MB memory and 16 each 2.9GB disk drives is planned for this year.

The following projects are defined in EDM:

- CAPDS Test and development pre and post PDS implementation.
- PDS Production PDS Environment.
- ADASA SDRC Analysis Models and Data.
- TOPS Pre PDS Technical Operations area.
- POPS Production Operations use non-PDS.

- FAC Facilities use non-PDS.
- REL Pre-PDS Released CAD data.
- LIB Released CAD Library data.
- SYSCONFG Sun Software Configuration Management
- MISAppls MIS Applications development and software storage area.
- MISDBA DBA test and development area.

7.0 Current EDM Activity:

Based on data gathered for the four month period starting November, 1994 and ending February, 1995.

- EDM Manages 65,149 Total Files (Feb. 1995).
- - 18,693 CV CADDs Parts consisting of 55,348 files.
- - 9,801 "other" Files.
- EDM supports an average of 105 users per month.
- EDM averages 1560 transactions per day.
- EDM averages 39,000 transactions per month (range = 29,000 to 51,000).

8.0 Lessons Learned:

Approach:

- The new environment should be described by the "visionaries" without the "real world" constraints of existing technology, budgets, resources, or schedules to arrive at the conceptual requirements. It is the role of the implementors to apply those real world constraints to the final picture of the new environment and negotiate with management and users to achieve the highest level of completion within the confines of technology, budget, available resources, and schedule. The visionary and implementor cannot, in most cases, be the same personnel.
- Planning and Testing should be the most important and time consuming steps in the implementation process. As we all know, whatever can go wrong will. Things like vendor's software not performing as documented or as we understood, or the best planned processes have an overlooked step, which is a "must have" and inflicts the greatest impact on what has been accomplished to-date, but was overlooked because "everyone knows that".

Planning:

- Document and understand how the intended system users do business today and how they and management want to change it.
- Have a clear understanding of where your company wants to go. Document and understand the long-range to-be environment. This should be considered your wish list. Without this visualization, it is very difficult to map out what needs to be changed, what tools to use, and what impacts current decisions / changes (and there will be some) will have on the final environment.
- Most things done today are driven by two paradigms which must be overcome:
 - That's the way we have always done business mentality.
 - The inherent serial process of a paper driven world.
- The net result of implementing a data management system does not mean instant process improvement. If the process is flawed or not suitable for automation, all that results is the problem is created quicker and in more volume.
- Involve your users. Don't just give them what you think they need. Their involvement in the definition, testing, and modification is crucial to the acceptance and utilization of the completed system. Give them some ownership. It will not matter how good a system you develop if no one is willing to use it. One way to accomplish this is to establish a user based team which is empowered, both with the authority and accountability to implement EDM. This team should understand and accept the project goals.
- Use the user team to establish initial standards for file naming, attributes, and what EDM functions will be allowed and which will not be allowed.

Testing:

- Utilize the user team to build and test scenarios which will exercise both the processes and the EDM tool.
- Model and incorporate processes, tools, customizations, and procedures in simplistic building block scenarios, which can be integrated into a complex environment. This will simplify debugging and minimize impacts due to failure or decision changes.

Customization:

- Avoid the tendency to over customize or over complicate the tool by implementing all the "bells and whistles" just because they are there and not because there is a requirement for them.

- Customization should be kept to a minimum.
- There is a lot of benefit from the use of the KIS (Keep It Simple) approach.
- The amount of customization has a direct impact on the amount of overhead support required to maintain it in the long run. It becomes your responsibility to test and migrate this customization each time the vendor releases updated versions (as often as every six months). The more elaborate the customization the greater the impact if the vendor changes a function or worse yet, no longer provides or support that function.
- Apply rules to customization
 - If the process can be changed, change the process not the system.
 - Where possible create external customizations which utilize the CI and API interfaces as these will have the greatest resistance to vendor induced changes and reduce the impacts of new version releases.
 - When customizing EDM, keep internal (EDM) changes as simple and modular as possible.
- Be aware of a potential void between the perceptions of the developers and the end users in what needs to be changed and how best to correct it. Let the users drive the changes.

Implementation:

- Change, no matter what the gains, is hard to accept. There will be resistance.
- Sell and keep selling the benefits to the users. Get management at all levels involved in this selling activity. It is the users who will make or break an implementation.
- Keep the users involved. This will give them ownership of the end product and improve its acceptance.
- No matter how well you test, there will be problems as you begin to transition to a production environment. Successful implementation planning and testing only minimize these problems.
- Implement in phases if possible, adding users, turning on functions, or adding customizations. This will minimize impacts if there should be a failure.
- **START!!** There will always be something better coming from the vendors. Set an implementation start date and if there are justifiable benefits to be had,

begin with what is available. Otherwise, you may find that you can never get out of the planning stage. Just remember to keep your eye on what the final goal is and adjust as necessary to get there.

In Summary:

The bottom line is time spent planning and scenario testing before the first piece of product data is input into EDM will payoff ten fold downstream. The more you involve your users the quicker the system will be accepted. The more you understand EDM's short falls and limits the better you can avoid or build around these problems. The physical problems such as hardware, network, and intended use will vary from site to site. These things will surface as you test and begin to implement. Plan for them by developing a phased implementation which allows for a slow build up of usage and provides for roll back if problems develop. I also eluded to conceptual requirements earlier; these were what we felt would be an ideal system. These need to be flexible, through testing, role playing scenarios, and user feedback they will evolve into the real requirements for the system. Lastly, implement only what you can touch and feel in the released version of the application. Things which are coming (according to the vendor) sometimes never do and things in the "beta" versions have a habit of disappearing at release. These "little" things can reap havoc on implementation schedules.

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10. The session be: () Closed () Limited Attendees or Open

11. Please indicate:

- (a) Is this meeting an international meeting? Yes () No
- (b) Is this meeting an industry to government meeting? () Yes () No
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I certify that the answers given by me are true, correct and complete to the best of my knowledge.


Signature

Date

3/29/95

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